Mesoscale Dynamics of the Adriatic Sea

Benoit Cushman-Roisin
Thayer School of Engineering
Dartmouth College
Hanover, NH 03755-8000
phone: (603) 646-3248 fax: (603) 646-3856 email: Benoit.Cushman.Roisin@dartmouth.edu

Award Number: N00014-02-1-0065
http://thayer.dartmouth.edu/other/adriatic/mesoscale/mesoscale.html

LONG-TERM GOALS

A better understanding of oceanic variability via modeling studies of circulation, entrainment, mixing and convection in the coastal ocean. Development and use of high-resolution models for the study of dynamic processes and for the investigation of specific oceanic regions. Transition of these models to the US Navy.

OBJECTIVES

The particular objective of this project is to understand the physics of the mesoscale motions across the Adriatic Sea well enough to simulate them faithfully in high-resolution models.

APPROACH

The selected model is DieCAST because of its extremely low level of dissipation at the grid scale (about 2 km in the horizontal), and forcing fields are interpolated from COAMPS data sets (from the NRL in Monterey). In-situ data used for validation are surface drifter trajectories (from OGS in Trieste). Model results are sampled where drifter data exist, and identical statistics are performed on both drifter speed and simulated currents. In particular, mean and turbulent kinetic energies are calculated and compared. The project is integrated in the ONR-sponsored Dynamics Of Localized Currents and Eddy Variability In The Adriatic (DOLCE VITA) Program.

WORK COMPLETED

The DieCAST ocean model, applied in a high-resolution mode to the entire Adriatic Sea, was used to simulate surface currents during periods for which there is better-than-average drifter trajectory coverage, so that drifter and model statistics could be compared. These periods were: 1-23 October 2002, 1-25 February 2003, and 1-30 June 2003. Interestingly enough, some of the selected periods coincided with strong wind events, either bora and sirocco. The corresponding COAMPS datasets were obtained and mapped onto the DieCAST model grid. Prior model spin-up was performed with climatological fields for 3 months. Forcing was then switched to the COAMPS data, and the simulation continued for a month or more. During the selected comparison periods, surface currents were sampled from the model results at times and places were drifter velocities are known so as to create two surface velocity sets of identical size. At each available location (5x5 model grid box with

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **30 SEP 2007**	2. REPORT TYPE **Annual**	3. DATES COVERED **00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE **Mesoscale Dynamics Of The Adriatic Sea**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Dartmouth College,Thayer School of Engineering,Thayer School of Engineering,Hanover,NH,03755-**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

5 or more drifter data), means and variances were calculated from the time series and transformed into mean kinetic energy (MKE) and turbulent kinetic energy (TKE), per mass (units of cm^2/s^2).

RESULTS

Comparisons of MKE and TKE between model simulations and drifter trajectories are favorable, but, of course, one looks for differences more than similarities in order to obtain insight about ways to improve the model. For October 2002, a period during which the Western Adriatic Current (WAC) was particularly strong, drifter data show high values of both MKE and TKE all along the Italian Coast, and the model behaves likewise except that its MKE is lower and TKE higher (Figure 1). In order words, the model overestimates the WAC's meandering and eddying. This indicates that the model is insufficiently dissipative.

For February 2003, a time of strong bora wind, the model performs nearly identically to the drifter data, except at the southern tip of Istria and along a line extending southwestward from there. This is where the bora generated an intense cross-cutting jet, and the model underestimated its strength. The model is not wrong *per se*, but its "surface" velocity is by design the velocity averaged over the top 5m of the water whereas drifters sample the velocity in the only top 1m of the water. Naturally, a swift wind creates a drift current highly sheared in the vertical, and the difference between 1m and 5m can be significant. The remedy is to increase the model's vertical resolution near the surface so that its top velocity is more representative of what drifters actually measure.

For June 2003, a time of pronounced cross-basin jets and gyres, the comparison between model results and drifter data is excellent, with a slight degree of overestimation of TKE by the model, suggesting once again that the model is insufficiently dissipative.

IMPACT/APPLICATIONS

The results to date demonstrate that effective simulations of the mesoscale variability of the Adriatic Sea require a low-dissipation model, a grid resolution of at least 2 km, realistic surface forcings (wind stress, heat flux, etc.) of similar spatial resolution, AND a turbulence closure for near-surface mixing. This ought to impact the Mediterranean Sea models currently used by the US Navy. It also leads us to anticipate success when DieCAST is later configured with data assimilation.

RELATED PROJECTS

This project is a component of the multi-project DOLCE VITA Program funded by ONR-PO and focusing on the Adriatic Sea. Related projects are those of Craig Lee (Univ. Washington, TriSoarus towed profiling), Pierre-Marie Poulain and Elena Mauri (OGS-Trieste, surface drifters), and Mirko Orlic (Univ. Zagreb, East Adriatic Coastal Experiment).

PUBLICATIONS

1. Lee, C. M., M. Orlic, P.-M. Poulain and B. Cushman-Roisin, 2007: Recent advances in oceanography and marine meteorology of the Adriatic Sea, *J. Geophys. Res*., **112**, C03S01, doi:10.1029/2007JC004115.

2. Cushman-Roisin, B., K. A. Korotenko, C. E. Galos and D. E. Dietrich, 2007: Simulation and characterization of the Adriatic Sea mesoscale variability, *J. Geophys. Res*., **112**, C03S14, doi: 10.1029/2006JC003515.

3. Cushman-Roisin, B., and K. A. Korotenko, 2007: Mesoscale-resolving simulations of summer and winter bora events in the Adriatic Sea, *J. Geophys. Res*., in press.

4. Willmott, A. J., and B. Cushman-Roisin, 2007: Barotropic instability of coastal flows as a boundary-value problem; linear and nonlinear theory. *Geophys. Astrophys. Fluid Dyn*., favorably reviewed.

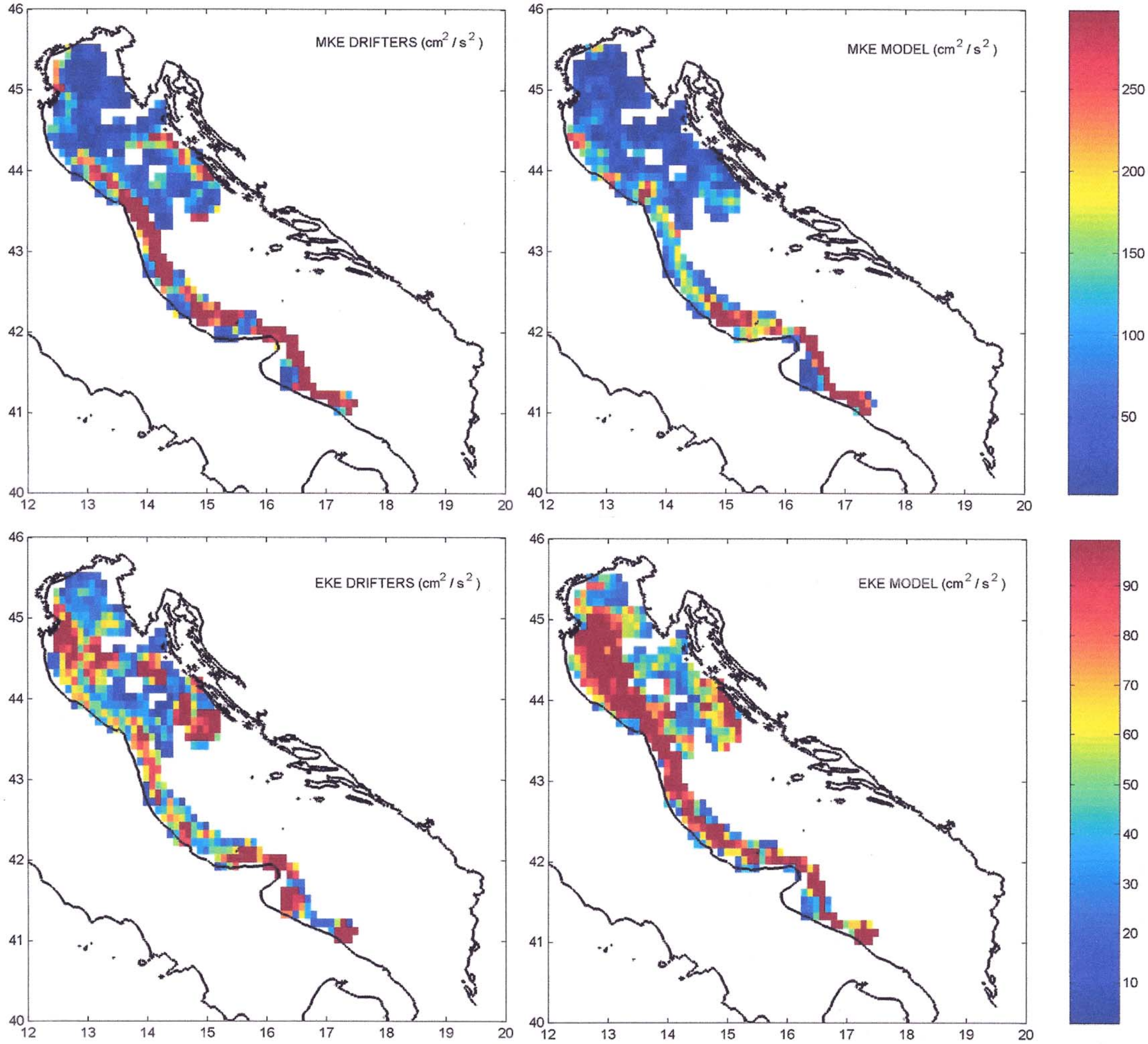

Figure 1. Comparison of surface mean kinetic energy (MKE – top row – values ranging from about zero to 300 cm^2/s^2) and turbulent kinetic energy (TKE – bottom row – values ranging from about 10 to 100 cm^2/s^2) calculated from both drifter trajectories (left panels) and DieCAST model simulations (right panels) for the period 1-23 October 2002. Blank areas indicate regions of insufficient drifter data (less than 5 per box). This period was one of intense flow down the Italian coastline and of complex flow in the northern basin. The model faithfully reproduces regions of strong/weak mean flow and low/high variability. However, discrepancies in values (MKE lower in model by 10% and TKE higher in model by 20%) indicate that the model overestimates the meandering and eddying of the coastal current along Italy, and this is attributed to insufficient dissipation on the part of the model.